Abiding by the rules? A sequential mixed-methods study on the determinants of regulatory compliance with maritime environmental legislation

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Published in:
Maritime Business Review

DOI:
10.1108/MABR-09-2018-0034

Published: 18/03/2019

Document Version
Peer reviewed version

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Research Paper submitted to WCTRS – SIGA2 – Maritime and Ports

Abstract

Purpose: Increased political measures to protect the marine environment address a shipping industry characterized by strained financial resources, excess supply of capacity, and consolidation.5-15% of industry participants are believed by shipping experts to neglect rules on vessel-source pollution to stay competitive within their industry and vis à vis other transport modes. This study aims to identify and quantify cost effects of maritime environmental legislation, to relate these with company characteristics, and to investigate the impact of regulatory compliance.

Design/Methodology/Approach: A mixed methods design was employed to develop both a theoretical model of compliance costs effects and to quantify effect sizes. Twelve in-depths exploratory expert interviews were conducted and analysed. A theoretical framework emerged that was evaluated, strengthened and fed with quantitative data from questionnaire data by 120 shipping companies. Partial least squares analysis was conducted to determine compliance cost effects.

Findings: It was found that organizational capacities played a significant role in determining compliance behaviour. Exterior determinants showed no significant correlation with legal compliance. This is a striking result, as it does not support achieving legal compliance with measures of strong enforcement.

Social implications: European transport policy making depends on scientifically sound studies on the impact of policy. An in-depth impact assessment on environmental legislation for the maritime industry highlights mechanisms applicable to environmental policy making in transport and helps in building policy that considers compliance concerns, company characteristics and the interconnectedness of different transport modes - for a sound response to the tragedy of the commons.

Originality/ value: Originality lies in the inductive development of a comprehensive theory on shipping companies' legal compliance behaviour as well as the empirical testing of this theory. Further value is derived from applying a sequential mixed methods approach to the research problem, showing both the worth and challenge in combining different methodologies to achieve sound research results.

Keywords—regulatory compliance, compliance costs, marine environmental protection, mixed methods research, clean vessel operations, North and Baltic Sea area.

Introduction

This paper studies the impact of legal compliance on compliance costs with maritime environmental legislation as part of a more comprehensive research project on compliance cost effects. The commercial shipping industry is characterized by increased possibilities to avoid regulation via moving assets that may easily be relocated to other jurisdictions, varying levels of enforcement of international rules in port states, global commons in the form of international waters where enforcement is hardly possible, at times colliding interests between flag and port states as regards environmental protection and offering low-cost solutions to shippers and, according to Tan, 'a generally secretive and fragmented nature'. (Tan, 2006, p.6) Regulatory avoidance and free-riding are inherent to the sector, a recent OECD report argues. (OECD, 2014, p.86) This international, hard-to-regulate-or-control industry is increasingly faced with legislative endeavours to protect the marine environment, particularly in specially protected areas, like the North and Baltic Sea. If shipping companies' decisions are based on cost-benefit considerations, it is likely that incentives to violate cost-incurring environmental rules will increase with cost pressure.

The researchers briefly discuss advances in maritime environmental legislation and their cost effects, the concept of regulatory compliance, and the associated rational choice approach. A model of compliance determinants developed inductively from qualitative data analysis and a review of prior studies is presented. A concise presentation of the methodology applied is ensued by a discussion of results of the quantitative study, involving partial least squares analysis of questionnaire data. Statistical results are discussed and compared with theoretical concepts. The present study serves to enhance knowledge of compliance behaviour and contributes to a fit-for-purpose assessment of existing and future maritime environmental legislation.

Novelty of this study stems from both the theoretical model of compliance determinants and empirical testing of the model. The path model is based on literature review – leading to a comprehensive sketch of compliance drivers specifically focused on the shipping industry – as well as knowledge gained from 12 in-depth expert interviews to enrich and refine that model. Empirical testing is done with data from 120 questionnaires distributed to owners and operators of commercial vessels in the North and Baltic Sea area. This research is relevant in providing a consolidated, consequentially organized model of determinants of compliance for the shipping industry based on prior studies, qualitative content analysis of primary interview data and statistical analysis of primary questionnaire data. Special considerations applicable to the shipping industry are explored and the model developed stands as a first to empirically test determinants of compliance behaviour with maritime environmental legislation.

Maritime environmental legislation in the North and Baltic Sea area

Environmental legislation to protect sea areas from harmful vessel-source emissions has received increased attention in recent years. With the aim of fostering cleaner ship operations, stricter legislation has been passed on the national and international level. Rules on sulphur and nitrogen oxide emissions, the introduction of invasive alien species through ballast water and other sources of pollution are currently being phased in or will soon come into force in the North and Baltic Sea area. Examples of such rules sorted by type of pollution are listed in Table 1. The law demands that measures must show positive effects, e.g. on the health of the marine environment and society, in excess of potential negative economic and social effects, e.g. in the form of more expensive transport services. (Marine Strategy Framework Directive, Art. 8). Compliance may lead to more efficient operations. It is however prone to increase costs to industry, thus raising the likelihood of deviant behaviour.

Oily water (Prohibition of all operational discharges of oil)	Applicable from 2002/2004/2005 (IMO, 1973, MEPC, 2002, 2004, 2005)
Garbage (Prohibition of all operational discharges of garbage)	Applicable from 2000 (MEPC, 1991, European Parliament and European Council, 2000, MEPC, 2013a)
Hull coatings (Prohibition of all hull coatings containing TBT)	Applicable from 2008 (IMO, 2008)
Air pollution I (Limitation of the amount of sulphur in fuel to 0.1%)	Applicable from 1 January 2015 (IMO, 2005)
Air pollution II (Mandatory energy-efficient operations lowering CO_2 emissions)	Applicable from 2019 (MEPC, 2013b)
Air pollution III (Mandatory nitrogen oxide tier III requirements)	Applicable for new-buildings from 2021 (MEPC, 2015)
Sewage water (Prohibition of all discharges)	Applicable from 1 June 2019 for new vessels and 2 June 2021 for existing vessels (MEPC, 2011)
Ballast water (Mandatory management systems)	Applicable from 8 September 2017 (IMO, 2017)

Table 1. Examples of maritime legislation by type of pollution applicable on the North and Baltic Sea (Authors)

Costs of compliance with maritime environmental legislation

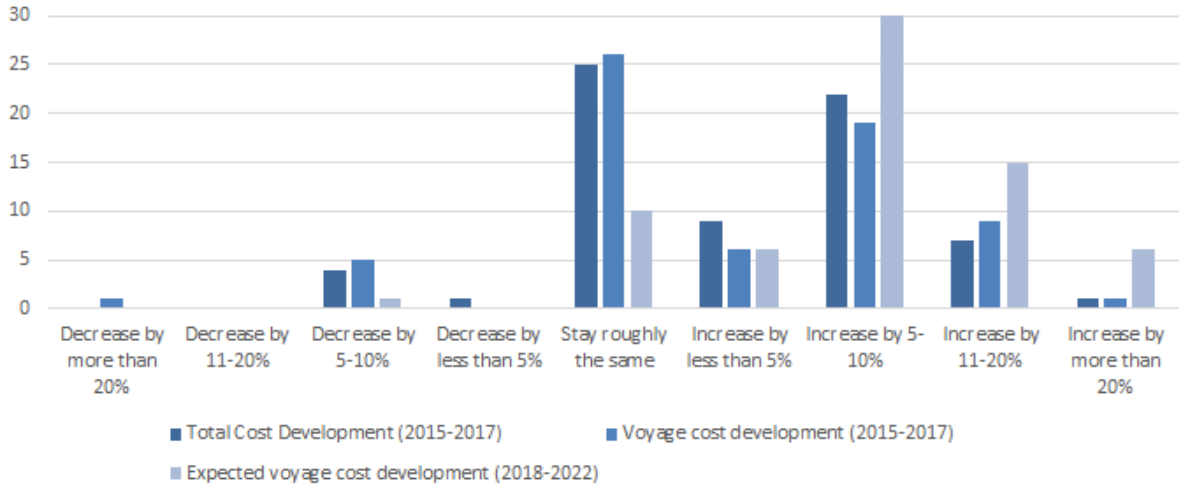
Estimated cost effects of maritime environmental legislation for vessel operations on the North and Baltic Sea stem from literature review and questionnaire data. Prior studies considering the combined cost effect of several environmental legal rules are difficult to come by. One study that accumulates costs of several measures was conducted by the OECD in 2003. Researchers estimated compliance costs at the time to reach around 3.5% to 6.5% of a ship's operating costs. (OECD, 2003, p.5) Scorpecci estimates that compliance costs in 2004 reached up to 20% of the vessel's revenue. He argues that with additional legislative measures, compliance costs will likely increase by 1.5 up to 3 times the amount of 2004 thus increasing the incentive for noncompliance. (Scorpecci, 2004, p.7) As these studies are quite dated, results may no longer be applicable. More recent studies usually consider a single legal endeavour. Several studies could be identified presenting cost estimates for compliance with stricter sulphur levels. Sampson et al. argue that the cost of compliance lies in the price differential between full compliance and noncompliance with legislation. (Sampson et al., 2016, p.300) Bell et al. discuss several categories of noncompliance costs, namely criminal liabilities (with rising fines and a rising willingness of regulatory agencies to prosecute), administrative sanctions (including suspension of licenses), clean-up costs (after pollution incidences; often exceeding the fines), civil liabilities (rather unlikely in the case of shipping), and adverse publicity. (Bell, McGillivray and Pedersen, 2013, p.39 et sqq.) The costs of noncompliance have been increasing in recent years, particularly driven by higher fines, increased controls, and a wider array of rules to follow. Taking sulphur legislation as an example, the costs of compliance are represented in the price difference between operating on distillate fuel or operating on high sulphur fuel and risking sanctions. The price of noncompliance may thus be defined as the level of damages from formal and informal institutions multiplied by the risk of detection. Depending on study

design, total vessel operation costs in North and Baltic sea are estimated to increase by 6% to 40% with the introduction of the sulphur emission control area (COMPASS, 2010, Notteboom, Delhay and Vanherle, 2010), indicating that the costs of a single measure may significantly exceed the dated OECD estimates. Studies on cost effects of NO_x tier III requirements foresee additional increases of 0.6% to 2.5% (COMPASS, 2010) or 6,500 to 400,000 EUR per vessel. (EPA, 2012) Installation costs for a ballast water treatment system are given at 100.000 to 1 million USD plus operating costs of 0.01 to 0.2 USD per ton of ballast water treated, depending on vessel size. (GEF-UNDP-IMO GloBallast Partnerships Programme and IUCN, 2010) As study designs differ, these costs may not be aggregated, but the approximate range of compliance costs becomes evident. Other environmental rules are likely to be less costly, but add further pressure on an industry characterized by overcapacities. (Morley, 2016) The 2003 OECD study calculated possible savings of up to $400,000 a year for a noncompliant vessel compared to a fully compliant one. (OECD, 2003, p.5) With new maritime environmental rules becoming effective in the next years, behaviour formerly not unlawful will be subjected to fines, increasing the risk of noncompliant behaviour.

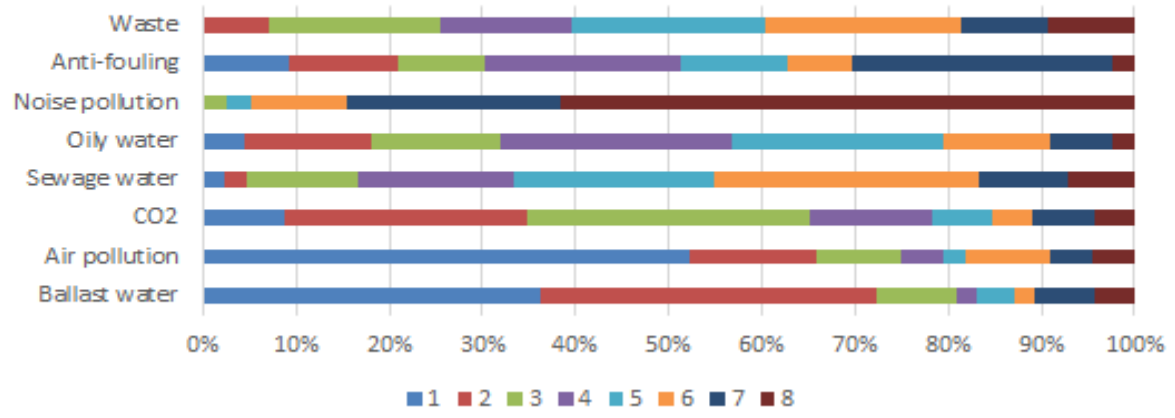
Cost accounting data collected through questionnaires suggests that while total costs stayed roughly the same between 2015 and 2017 for 36.2% companies, they increased for 56.5% of companies, with the largest group noticing an increase of some 5-10%. Voyage costs have behaved similarly in 2015-2017, with some 9% of companies even noticing a decrease and the majority experiencing slight increases in voyage costs. With a view to the future however, voyage costs are expected by most shipping companies to increase by some 5-20% until 2022. (see graph 1, n=69) These figures may be explained by low fuel prices in the period since 2015, which alleviated effects of price increases due to low sulphur legislation, while at the same time future expectations for fuel prices are leading to anticipated rising bills. Among other considerations, the certainty of phased-in environmental legislation may also play a role in this expected increase.

With respect to individual measures, graph 2 (n=47) shows results of a ranking by most expensive measure, indicating clearly that air pollution legislation (specifically measures to curb SO_2 and NO_x emissions), ballast water legislation and legislation on the reduction of CO_2 emissions are deemed the most expensive by the industry, while legislation on noise pollution is deemed the least expensive (which makes sense as there are of yet no measures in place), followed by antifouling legislation. A ranking on cost expectations for the years until 2022 (see graph 3, n=35) shows that the costs of ballast water legislation are expected to surpass the costs of air pollution legislation. An increased importance of measures on CO_2 reduction between 2017 and 2022 may also be conjured from graphs 2 and 3. Interestingly, despite its effect on costs, legislative compliance seems no significant determinant of freight rates for shipping companies. Other factors, like changes in the demand for transport capacity, changes in fuel costs irrespective of environmental legislation, and changes in cargo-handling costs, are having a greater influence on costs and prices of shipping companies than environmental legislation. This becomes apparent from graph 4 presenting a ranking of factors by their influence on freight rates.

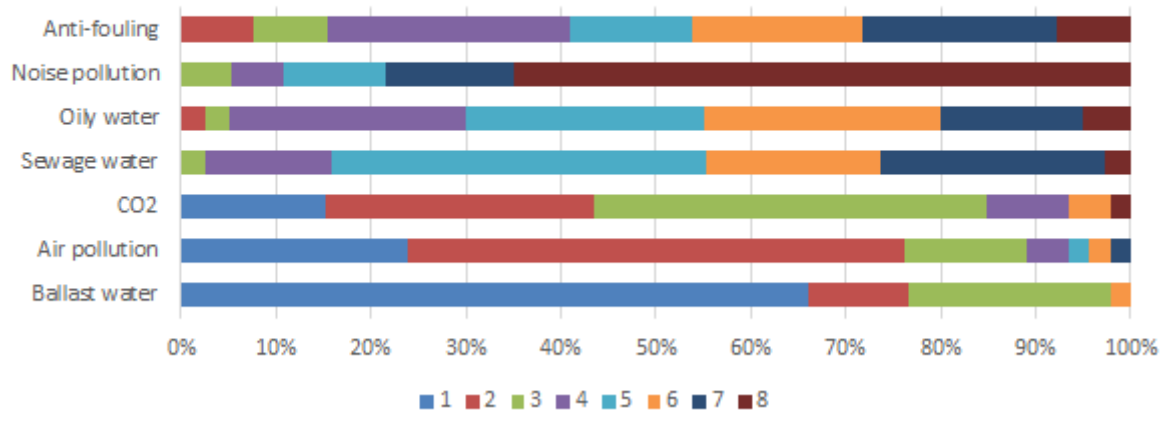
Graph 1: Development of total costs and voyage costs (2015-2017) and expected voyage cost development (2018-2022)

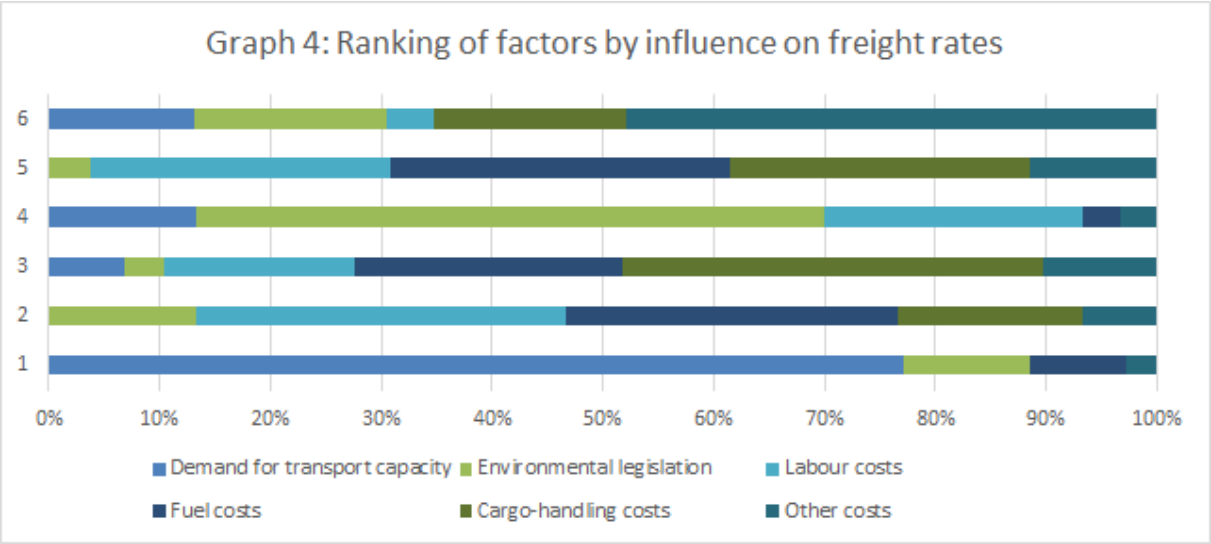


Graph 2: Ranking by most expensive legislative measure (2015-2017)



Graph 3: Ranking by most expensive legislative measure (2018-2022)





Graphs 1-4: Total cost development and voyage cost development (2015-2022), Ranking by most expensive legislative measure (2015-2022), Ranking of cost factors by influence on freight rates (2015-2018) (Author)

Regulatory compliance

Definition of regulatory compliance

The concept of regulatory compliance applied here follows a letter of the law approach as dissociated from behavioural definitions used in the social sciences and is defined as the conformity of an organization's behaviour with a prescribed legal rule. (Mitchell, 1994, p.30) Noncompliance is thus a deviation from prescribed legal behaviour. If one wants to measure all cost effects of legislation, however, changes of behaviour within the organization leading to cost increases need to be considered, even if they do not lead to a fully compliant organization. Recently researchers have suggested replacing the concept of regulatory compliance with the concept of corporate social responsibility (CSR). (Snezhko and Coskun, 2019) This approach seems insufficient to study the behavioural effect of legislation. Ethical considerations may induce a company to do more or less than legally prescribed. CSR may thus influence regulatory compliance, but a compliance decision will depend on more than ethics, as described below. Current research is also conducted on contractarian environmental legislation, where regulators refrain from enforcing certain laws in exchange for an organization's commitment to fulfil obligations not required by law. A thorough discussion of this decentralized approach to policy-making can be found with Dana. (Dana, 2018) It currently finds no application in the area of maritime environmental legislation and is thus not further discussed here. Raustiala and Slaughter provide a helpful definition stating that at its roots compliance is a concept of causality looking at the behavioural influences of legal rules. (Raustiala and Slaughter, 2002, p.539) Behaviour is relevant to the present research if it is directly or indirectly induced by maritime environmental legislation *and* leads to costs in terms of money, time, or other resources. Where legislation has no effect on costs it can be assumed that incentives for noncompliance are nil.

Compliance and rational choice

Following a law and economics approach, this work links regulatory compliance to rational choice theory. The principle of compliance as a cost-benefit calculation has been described in a fundamental work on the economics of crime by Becker and defined further by his student Ehrlich. (Becker 1968; Ehrlich 1996) Applying a related definition by Posner, shipping

companies are likely to 'economize by buying less of a good or commodity when its price rises' (Posner, 1974, p.763), specifically they are likely to invest less in compliant behaviour if compliance becomes costlier, assuming that costs of noncompliance stay the same. Rational choice theory applies irrespective of whether compliance occurs willingly or unwillingly, termed 'committed compliance' and 'capitulative compliance' by McBarnet. (McBarnet, 2019) As stated above however, costs of noncompliance may be increasing simultaneously. Simpson and Rorie present compliance behaviour as a rational choice of companies between several alternatives. Noncompliance thus occurs where the benefits of unlawful behaviour outweigh the costs of compliance. (Simpson and Rorie, 2011, p.60 et sqq.) Costs in this respect depend on preferences of individual decision-makers, as the value of morality, for example, differs between individuals. In this context it needs to be noted that noncompliance may both be a product of action or inaction. (Cohen and Simpson, 1997) When applying rational choice theory to compliance, limits to rationality need to be considered, like a lack of access to information, individual characteristics of companies, and circumstances. Simpson and Rorie thus propose an objective utility approach signifying that costs and benefits are 'perceptual, rather than objective'. (Simpson and Rorie, 2011, p.61) Perceived costs and benefits of a certain legislative endeavour may differ between companies and may lead to dissociated behavioural outcomes. Rational choice theory tells us that shipping companies' incentives to violate the rules are likely to increase with augmented cost pressure. Environmental pollution being an externality, companies would generally only take their individual costs, not the costs to society, into consideration. (Phaneuf and Requate, 2017, p.5)

Practical relevance of noncompliance with maritime environmental legislation

Studies on environmental compliance exist for organizations in general (i.e. writings on corporate crime), but are very rare for the commercial shipping industry, with the exclusion of fisheries, where the study of overfishing has received increased attention. This research gap may be due to the hard-to-grasp characteristics of the industry discussed above. A rare exception is the above-mentioned 2003 OECD report, estimating that around 10-15% of the world fleet is operated 'in full contravention to the IMO's body of environmental regulations'. (OECD, 2003, p.4). These numbers may in the meantime have become outdated and the report provides no distinction between different company sizes, flag states, areas of operation or other, but gives a vague indication that noncompliance with maritime environmental legislation may be of relevance. Further evidence on the practical relevance of noncompliance stems from the annual reports of the Paris MoU on Port State Control. The 2016 report shows that pollution is the number three reason for detention of vessels in European harbours. Noncompliance is regularly found with respect to rules on oily water (1.7% of deficiencies), sewage water (0.8%), garbage (1.3%) and air pollution (1.0%), while unlawful anti-fouling coatings are only detected in a negligible number of cases. (Paris MoU, 2017, p.48) Ballast water systems do not yet figure in the 2016 report, as they only became mandatory in September 2017. As port state control officers mostly control vessels particularly suspicious of noncompliance, i.e. black-listed vessels, these numbers provide limited evidence on the overall level of compliance with environmental legislation within the shipping industry. Data on compliance behaviour has been measured via questionnaires to build a compliance indicator as described below.

Mixed methods study

Method of the study

The present study is exploratory in nature. A mixed methods approach was chosen to facilitate the generation and testing of an original theoretical framework to investigate the research problem. Twelve in-depth expert interviews of 60 to 120 minutes length have been conducted by the researchers in 2015 and 2016 to identify drivers of environmental compliance, enhance the depth of knowledge on existing determinants and highlight cases of variable

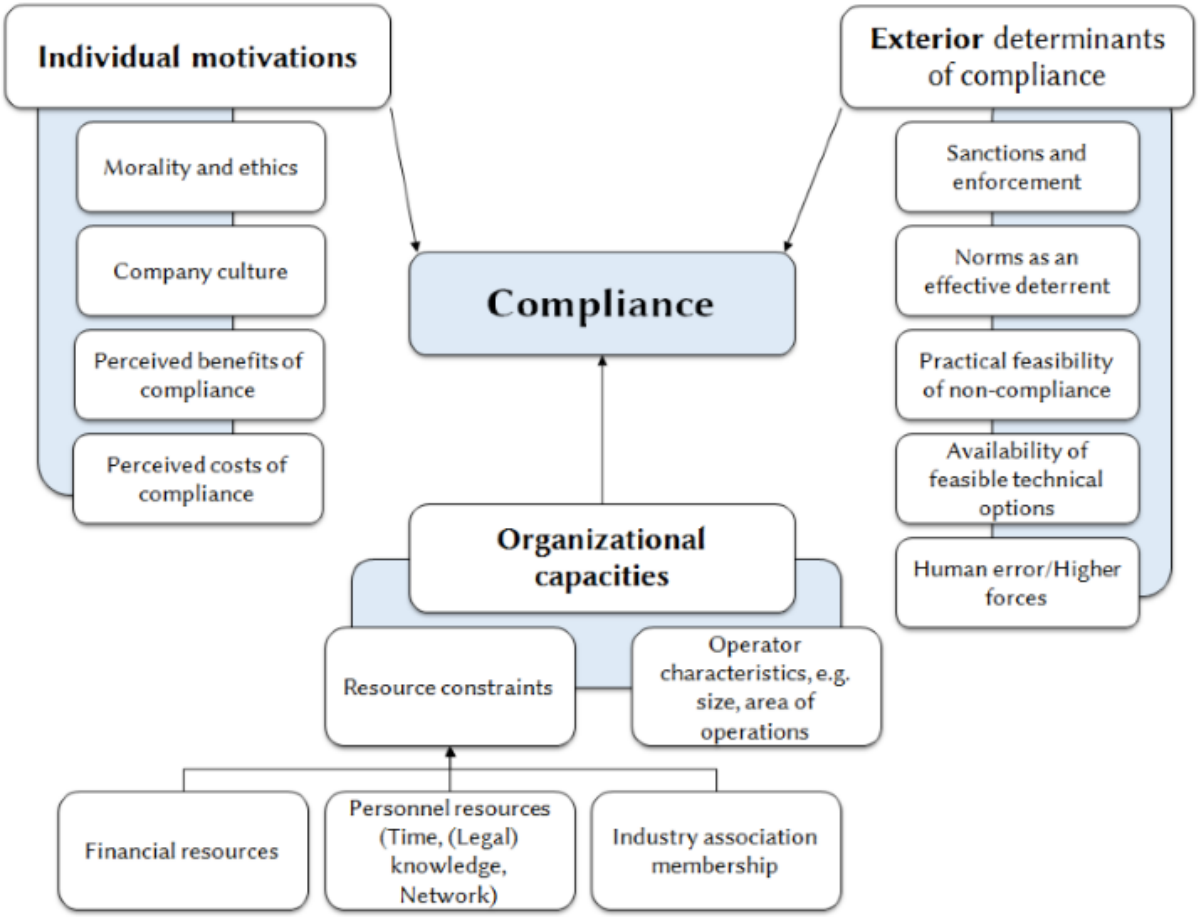
interdependency. Experts were purposefully sampled based on their superior knowledge on issues of maritime environmental legislation. Data acquired was fully transcribed, anonymized and translated into English where necessary. Guidance questions were related to the shipping companies' level of knowledge and understanding about environmental legislation, their motivations to comply, as well as the effectiveness of control systems and technical compliance options. A theoretical framework was built to serve as a basis for confirmatory quantitative analysis. A 12-page-long, 129-item self-completion questionnaire was drafted and distributed via personalized email to commercial shipping companies with offices in countries bordering the North and Baltic Sea. From a full sample of 829 companies, 149 questionnaires were received and 121 met basic criteria to be used for evaluation.

Data analysis was conducted using SPSS, Excel and SmartPLS. Multivariate analysis tools were chosen to test complex relationships between compliance variables. Partial-least squares structural equation modelling (PLS-SEM) is applied here, which is both able to explore patterns in the data and test the a priori established theories as laid down in the theoretical framework.

Theoretical framework

The development of the theoretical framework from qualitative content analysis and systematic review of prior studies as presented in Graph 5 is described in detail in a working paper by Freese and Gille, available on Researchgate (Freese and Gille, 2017), and will not be detailed here. It suffices to point out that 13 determinants were inductively developed, which were clustered under three theoretical concepts, namely individual motivations, organizational capacities and exterior determinants. Items in the questionnaire relate to these theoretical concepts and data on proxy variables is collected to evaluate the statistical significance of theoretical relations.

Graph 5: Theoretical framework of determinants of compliance based on exploratory qualitative study and literature review

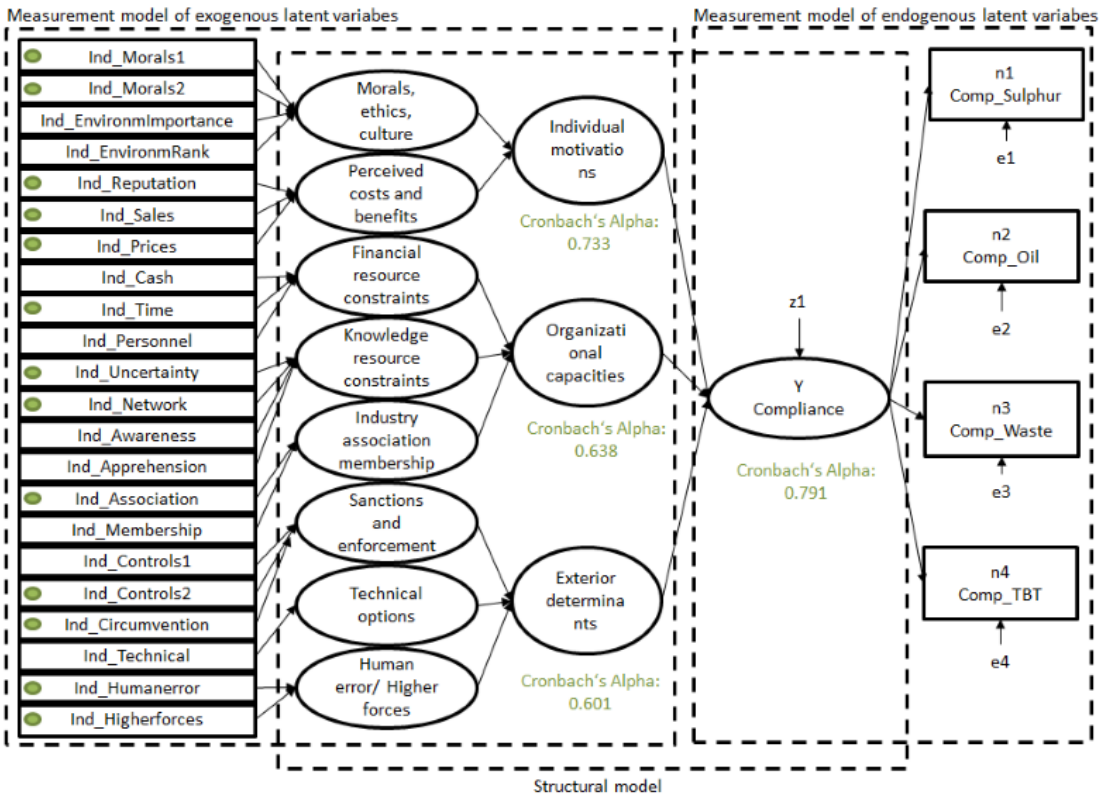


Graph 5. Theoretical framework of determinants of compliance based on exploratory qualitative study and literature review (Authors)

Path model with latent variables

A path model developed based on the theoretical framework can be found in Figure 6. Path models are widely applied to visualize variable relationships and hypotheses in SEM. (Hair, Ringle and Sarstedt, 2011) Both measurement theory and structural theory are shown in the graph. In this context, a formative measurement model is applied to identify drivers of compliance. Multi-item scales are used to increase predictive validity in line with recommendations by Diamantopoulos et al. (Diamantopoulos et al., 2012) Cronbach's Alpha was employed to determine reliable proxy variables. Indicators were eliminated until Cronbach's Alpha exceeded 0.6, leading to the exclusion of some measurements. 'Individual motivations' eventually relies on five indicators with a Cronbach's Alpha of 0.733, 'Organizational capacities' relies on four indicators with a Cronbach's Alpha of 0.638, and 'Exterior determinants' relies on four indicators with a Cronbach's Alpha of 0.601. The researchers refrain from regression analysis based on sum scores (i.e. determining latent variable scores from average values of indicators) for the concepts, as it cannot be assumed that indicator weights are equal. Instead, partial least squares is employed as described below.

Graph 6: Path model (Structural and measurement model)



Graph 6. Path model (Structural and measurement model) (Authors)

Measures

Determinants of compliance were identified from literature research and expert interviews. Many of the drivers constitute complex concepts that are defined here as latent or unobservable variables. These constructs may not be directly measured but must be studied indirectly by using indicators. Proxy variables were created and combined to form a single composite score. Measurement error from poorly worded questions or misunderstandings was aimed to be reduced by using several items to measure a concept. While the compliance index was computed from 5-point Likert scales, data on compliance attitudes was measured on 4-point Likert scales, not allowing for a "middle option", but forcing a taking of sides. Likert items of all scales were symmetric around a middle item and equidistant and could thus be used in SEM. (Hair, Jr. et al., 2018, p.9) Control variables included were company size, area of operations, average vessel age and type of operations.

Missing data

The sample consists of 121 commercial shipping companies active at least at times in the specially protected areas of the North and Baltic Sea. As data on compliance behaviour is particularly sensitive however, a limited number of companies participating in the study have provided answers to all questions on compliance. Constructs are based on a minimum of 36 companies providing data. Companies having provided information on less than 85% of indicators were deleted from the sample for the purpose of this analysis, leaving 43 companies in the dataset. Hair et al. suggest using means of power analysis on the part of the model with the largest number of predictors as an indicator for minimum sample size. (Hair, Jr. et al., 2018, p.24) Following calculations by Cohen, with the maximum number of independent variables

being five, 37 observations would be needed to achieve a statistical power of 80% for detecting R^2 values of at least 0.25 (with a 10% probability of error). (Cohen, 1992) The sample size is thus deemed acceptable in the light of this being a study on a sensitive topic in a seclusive industry.

Missing data is dealt with in two different ways. Mean value replacement is applied if less than 5% of values are missing for an indicator. Other missing data is dealt with by pairwise deletion. Although this might lead to biased results based on different sample sizes per indicator, it seems the best choice in light of the data's many missing values. In these cases, mean value replacement would lead to a decrease in variability and thus explanatory power of the data and casewise deletion would further shrink the already small dataset.

Data analysis

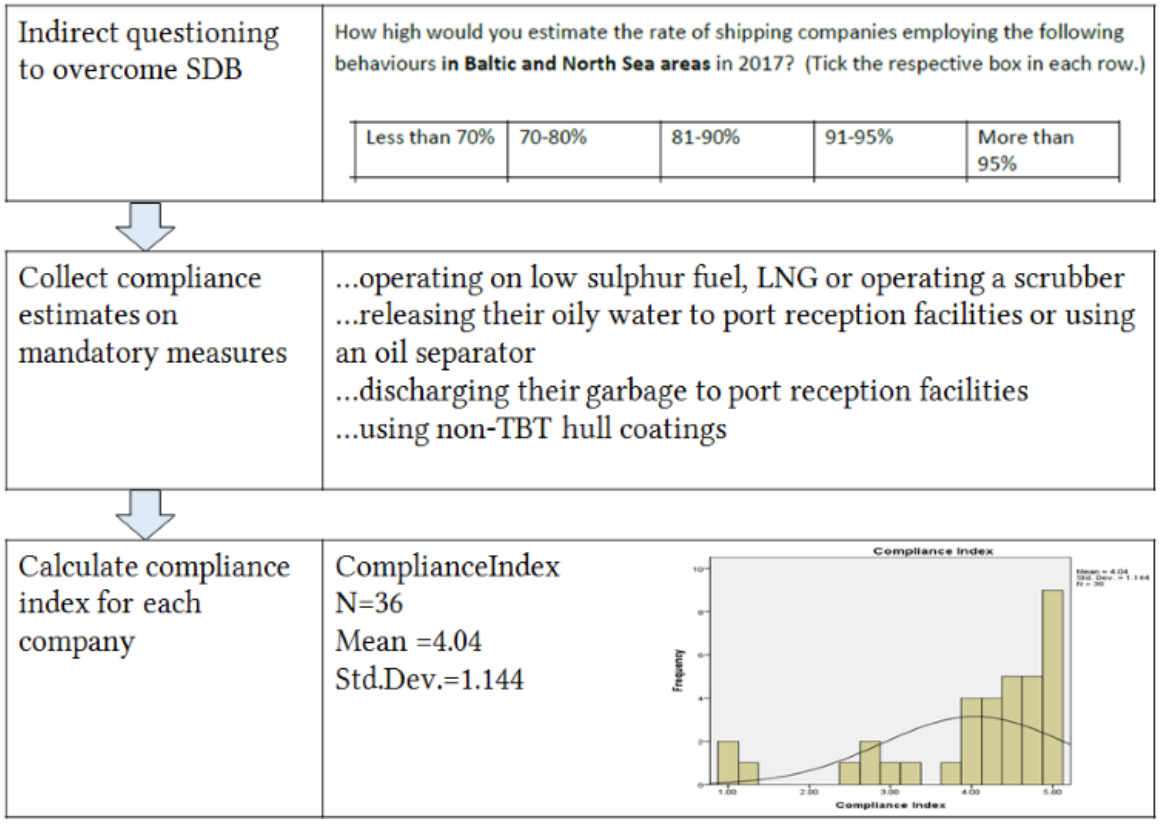
Partial least squares (PLS) was chosen as a modelling technique, as it proves apt to deal with specific challenges of the data at hand. PLS consists of a series of ordinary least squares (OLS) analyses and is a two-stage technique where first the outer model is evaluated in terms of reliability and validity and then the inner model is assessed. This structural equation modelling technique is able to handle small sample sizes, has minimal demand on measurement scales, can deal with violations of the normality distribution assumption and is robust with respect to multicollinearity. (Wold et al., 1984) It also treats proxy variables as approximations of the constructs they replace, which is very fitting in this study, and makes it a superior method to CB-SEM for the study at hand. (Hair, Jr. et al., 2018, p.16) PLS may both be used to test theories and find relationships between variables. It may be distinguished from more traditional methods of data analysis such as multiple regression in being able to analyse both manifest and latent variables alike. Unobservable variables may thus be measured indirectly. (Hair, Jr. et al., 2018, p.3) Measurement errors in observed variables may also be accounted for. (Chin, 1998) The characteristics and benefits of PLS-SEM are well explained by Hair et al. (Hair, Jr. et al., 2018) One drawback is the lack of a global goodness-of-fit measure. Henseler and Sarstedt introduced the standardized root mean square residual, SRMR, which is used here to measure goodness of fit. (Henseler and Sarstedt, 2013) The consistency of parameter estimates is another issue that needs to be accounted for. Parameter accuracy is however viable, when measurement models meet certain standards, i.e. having four or more indicators with indicator loadings of ≥ 0.7. (Astrachan, Patel and Wanzenried, 2014) These standards must be taken into account to ensure parameter accuracy.

Social-desirability bias and the compliance index

Self-reported compliance attitudes and compliance behaviour are likely to be influenced by social-desirability bias (SDB), leading to underreporting of noncompliance. (Brace, 2013, p.210) Asked for their perceptions on compliance, 95.3% of participants reported that the phrase 'My company would not do anything that is against the law' was 'absolutely true'. Research on SDB shows that simply asking participants for honesty is to little avail to overcome the bias. (Phillips and Clancy, 1972) Techniques used in this survey are the omission of a respondent identifier, assurances of confidentiality, anonymous data collection via on online survey tool, and indirect questioning. In a review of prior studies Fisher found that indirect questioning reduced SDB on variables subject to social influence and that subjects effectively projected their beliefs and evaluations to indirect response situations. (Fisher, 1993) Brace presents indirect questioning as a viable method to overcome SDB, but highlights the danger that the researcher may not be sure about the percentage of participants who projected their own behaviour onto others and participants who honestly reported their judgement of others. (Brace,

2013, p.217) Being aware of this danger, indirect questioning was used to determine levels of compliance and build a compliance index as shown in graph 7. As overall compliance levels were estimated to be quite high by experts at the interview stage, compliance levels asked for in the questionnaires ranged from “less than 70%” to “more than 95%”. Projecting the indirect data onto the companies themselves, a compliance index was calculated for each company. It is important to notice that the underlying scale is not equidistant. An equidistant 5-point-Likert-scale would have yielded much less information, as the researcher already knew from expert interviews, what the relevant compliance categories were likely to be. All other Likert scales in the study are equidistant. The histogram shows a distribution with n=36 (as many participants refrained from answering questions on compliance altogether), a mean of 4.04 (signifying overall estimated compliance levels around 95%, which is well in line with estimates from prior studies and expert interviews), a standard deviation of 1.144, and a non-normal distribution with a negative skew. It becomes apparent, that although the vast majority of companies in the sample exhibit very high levels of compliance, a small group of outliers can be found at the left-hand side of the graph indicating low levels of compliance. Cronbach’s alpha is 0.791, indicating internal consistency of the scale.

Graph 7: Compliance index calculation



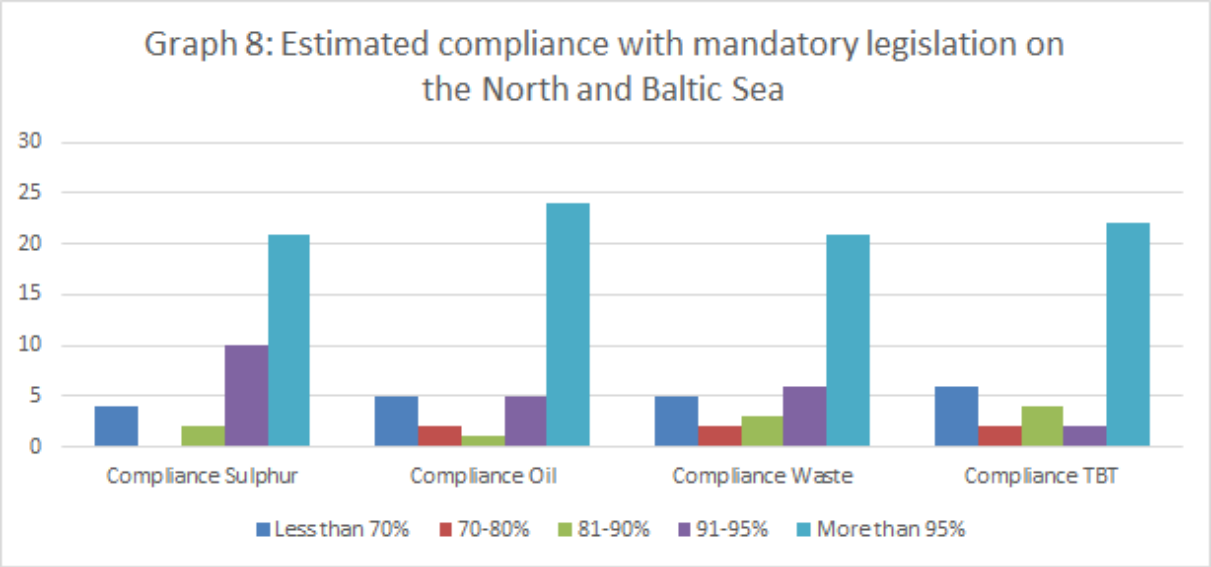
Graph 7. Compliance index calculation (Authors)

Results

Compliance rates

Graph 8 (n=37) shows the compliance rate by type of pollution as developed from questionnaire data. It becomes apparent that for some types of pollution compliance levels are estimated to be higher than for other types of pollution. While compliance with legislation on oil pollution,

the prohibition of TBT for hull-coatings and legislation on waste pollution are deemed to be complied with by more than 95% of companies on average, a significant number of participants estimate the compliance with sulphur legislation to be around 91-95%, while most estimate compliance rates to exceed 95% as well. Compliance with sewage water legislation exhibits a different pattern than all other initiatives, as it will only enter into force in 2019 and serves as a control variable here. Interestingly, a small number of companies accounting for some 10-15% of the sample estimate compliance rates for all mandatory measures to be below 70%. These companies are likely to be noncompliant themselves at least occasionally, following the theory of indirect questioning. This noncompliance rate seems to be in line with the 5-15% estimated by experts at the interview stage.



Graph 8. Compliance rate by type of pollution (Authors)

Compliance drivers

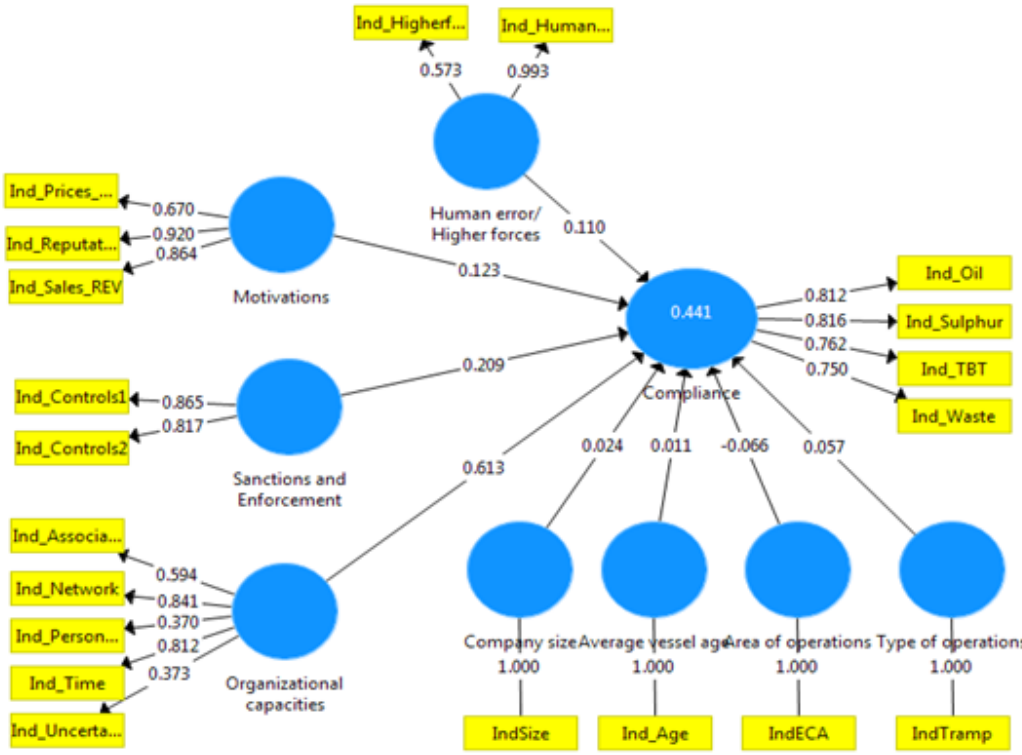
PLS-SEM was conducted as described above with results shown in graph 9 below. Histograms of constructs show approximately bell-shaped symmetric curves. While PLS-SEM does not assume a certain data distribution, it is important to assure that data distribution is not extremely non-normal, as that would lead to difficulties in assessment of parameter weights. Skewness and curtosis were used here to assess how data deviates from normality with a value lower than -1 or higher than +1 for both considered non-normal. The construct 'Motivations' is not normally distributed. The nonnormality of the construct stems from extremely non-normal distributions for indicators Ind_Morals1 and Ind_Morals2 as can be seen by their skewness and kurtosis. These indicators were thus eliminated from the set, leaving three indicators to explain the construct 'Motivations' with a healthy Cronbach's Alpha of 0.771. Other indicators were not deleted, even if their outer loadings were slightly below 0.7, so as not to decrease content validity (Hair, Jr. et al., 2018, p.113), but the construct 'Exterior determinants' was split into the two concepts 'Sanctions and Enforcement' and 'Human error/Higher forces' to increase content validity. No indicator showed outer loadings below 0.3, as these had already been removed when considering Cronbach's Alpha in preparing the data for analysis with PLS.

The R^2-value of 0.441 shows that around **44.1%** of variance in compliance behaviour may be explained by the exogenous latent variables. According to Ringle et al., this can be described as a moderate effect. (Ringle, Sinkovics and Henseler, 2009) Model fit is thus far from perfect but the model has moderate explanatory value. Not all path estimates are

statistically significant. Path coefficients have standardized values between -1 and +1. Any value close to 0 shows a weak relationship that is usually not statistically significant. As in indication it can be assumed that values above 0.2 are significant, which only is the case for the concept 'Organizational Capacities' with a path value of 0.613 and 'Sanctions and Enforcement' with a path value of 0.209. T-values and p-values determined through bootstrapping are shown in the table below graph 9. With a p-value below 0.01, organizational capacities were significant at the 1% level, while sanctions and enforcement could not be shown to be statistically relevant. As can be seen from the outer loadings below, particularly the indicators Ind_Time and Ind_Network have high loading factors on the concept 'Organizational Capacities', indicating that a lack of time and a lack of a network with other companies might be significantly related to a lower level of compliance with environmental legislation. The remaining two concepts determined from expert interviews and literature review could not be found to show a statistically significant relation with compliance rates. Instead, other drivers must explain deviations in compliance levels. Similar to other latent constructs, no significant relation could be found between control variables and compliance.

No universal measure for model fit is known for PLS. Root mean square residual covariance (SRMR) is used as one measure of model fit here. The model has an SRMR-value of **0.127**. A value of 0 generally indicates perfect fit, while a value below 0.08 indicates good fit when applied to CB-SEM models. Hair et al. argue however that this threshold is too low for PLS-SEM and propose applying a higher (though unspecified) threshold. (Hair, Jr. et al., 2018, p.193) SRMR does not indicate very good model fit. RMStheta is considered as a second measure of model fit with a value above 0.12 indicating a lack of fit. The value calculated in Smart PLS for the model at hand is RMStheta=**0.246**. This second measure indicates poor model fit. Further analysis and changes in model specification seem thus necessary.

Graph 9: Results from PLS analysis and bootstrapping on determinants of compliance



	Original Sampl...	Sample Mean (...	Standard Devia...	T Statistics (|O...	P Values
Area of operations -> Compliance	-0.066	-0.065	0.145	0.454	0.650
Average vessel age -> Compliance	0.011	0.046	0.247	0.046	0.963
Company size -> Compliance	0.024	-0.014	0.218	0.112	0.911
Human error/Higher forces -> Compliance	0.110	0.110	0.224	0.492	0.623
Motivations -> Compliance	0.123	0.079	0.258	0.479	0.632
Organizational capacities -> Compliance	0.613	0.581	0.228	2.683	0.008
Sanctions and Enforcement -> Compliance	0.209	0.212	0.160	1.303	0.193
Type of operations -> Compliance	0.057	0.076	0.183	0.311	0.756

Graph 9. Results of partial least squares analysis (Authors)

Reliability analysis

Measures of construct reliability are shown in the table below. As in this study new measures for concepts are developed, a Cronbach's Alpha of close to 0.6 is deemed acceptable, in accordance with assessments by Nunnally (Nunnally, 1978) and Hair. (Hair, Jr. et al., 2018, p.24) With well-defined constructs, a minimum of 0.7 is demanded to describe reliability. Composite reliability tends to overestimate reliability slightly, while Cronbach's Alpha might underestimate reliability for the type of study at hand, involving Likert scales with few points. Hair et al estimate that true reliability estimates lie somewhere between these indicators. (Hair, Jr. et al., 2018) Following that argument, concepts are shown to be reliable with composite reliability above 0.7 for all concepts and Cronbach's Alpha above or close to 0.6 for all concepts. These measures are comparable to other exploratory studies.

	Cronbach's Alpha	Rho_A	Composite Reliability	Average Variance
Area of operations	1.000	1.000	1.000	1.000
Average vessel age	1.000	1.000	1.000	1.000
Company size	1.000	1.000	1.000	1.000
Compliance	0.795	0.803	0.865	0.617
Human error/Higher forces	0.639	2.865	0.781	0.657
Motivations	0.779	0.943	0.863	0.681
Organizational capacities	0.595	0.692	0.748	0.399
Sanctions and enforcement	0.589	0.596	0.829	0.708
Type of operations	1.000	1.000	1.000	1.000

Table 2. Measures of construct reliability (Authors)

Main findings, limitations and further research

Study results show that organizational capacities of a shipping company, particularly available time to collect and apprehend legal information, a strong network with other companies, and membership in an industry association, are statistically significant and positively correlated with increased levels of compliance with maritime environmental legislation. All other constructs that were developed from expert interviews and prior studies could not be found to have statistically significant effects. These results are particularly striking in the case of controls and enforcement, which is traditionally seen as the main driver of compliance in economic theory. This driver, despite a significant loading factor on compliance, did not withstand statistical scrutiny of empirical data. The main research outcome is that companies with more resources at hand fare better in complying with environmental rules than companies with less available resources. These findings are however not statistically linked to company size, signifying that both larger and smaller shipping enterprises may be endowed with the necessary resources to make for a law-abiding market player. It seems that legal compliance is something that a company must be able to afford and that a player may consciously invest in by investing in personnel specifically tasked with following legal developments and building up relations with other companies to exchange information on new rules. Also, paying for industry association membership and making use of both information and relations will be strongly correlated with environmental compliance.

The rather poor overall model fit may be explained by a lack of correlation between compliance and compliance drivers identified, but may also be an effect of measurement errors, errors in translating the latent concepts into viable proxy variables or may be a result of the small sample size. Also, instrumentation of the questionnaire to receive a desired outcome is possible, where participants overestimate compliance costs and underestimate noncompliant behaviour to discourage further political involvement in the industry. The results are not atypical for exploratory studies, where tentative first steps are made to identify relationships between abstract concepts and much still needs to be learned in terms of describing and measuring the latent concepts. Also, the research shows the benefits of conducting mixed methods research. The theoretical concept presented above represent a convincing outcome of thorough qualitative research but does not seem to withstand statistical scrutiny.

Next steps would be the further development of indicators to describe latent variables and a further search for explanatory factors of compliance that are not represented in the theoretical framework so far. Also, statistical analysis based on a larger sample size would be

valuable to improve the analysis of compliance drivers and to further the understanding of regulatory compliance as a measure to improve environmental legislation.

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